BALANCING TECHNOLOGY AND RISK IN THE FUTURE COMBAT SYSTEMS

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1. INTRODUCTION

While all the lessons of *Operation Iraqi Freedom* will not be known for some time, one already seems clear: large, well-armed ground forces are still needed for many expeditionary wars. Heavy U.S. Army forces, however, still lack the capacity to deploy overseas swiftly enough to wage these wars. The result is a deficiency in the capacity of U.S. military forces to prosecute modern wars in distant areas. This will be especially true for wars in which air power is not a cure-all and major ground combat operations must be launched.

Addressing the problem of slow Army deployment rates, the *Army Transformation Roadmap* 2003 states the goal of transformation is to "identify and build required capabilities now…while developing future force capabilities essential to provide relevant, ready, responsive, and dominant land power to the Future Joint Force." Indeed, one aspect of the Army's transformation efforts is force redesign to develop an active component capable of deploying a responsive, agile expeditionary force in the first fifteen days of an operation.

Presently, much of the tonnage devoted to Army assets must be shipped by sea because the capacity of U.S. strategic airlift is insufficient to complete the task. Consider that each cargo ship must be individually loaded at ports in the continental United States, sailed thousands of miles, and offloaded at foreign ports. Loading and offloading a single cargo ship alone can take two or three days. For obvious reasons, this process can be quite time-consuming. If bottlenecks arise, such as a shortage of cargo ships or poor offloading facilities at foreign ports, the process can be considerably delayed. This reliance on slow-moving cargo ships to transport weighty forces lies at the heart of the Army's deployment problem.

How the Army achieves its transformational goal of rapid deployment depends upon its perspectives about weight. That is, transformation plans differ if the objective is weight reduction as opposed to weight redistribution. Weight reduction is primarily platform-centric and relies upon technological advances in materials and network technology to deliver a single lightweight platform capable of surviving heavy combat. Weight redistribution considers parameters other than platform weight and information to meet the Army's goals, to wit, forces are re-structured into small, modular units, pre-positioned across the globe, and deployed in a time-sequential manner. Although the second approach is less dependent upon technology, it is possible only if Army forces are considered malleable in time, space, and structure. In Sections 2 and 3 we consider the technological advances necessary to realize transformation based on weight reduction and in Section 4 we consider weight redistribution. Section 5 contains some final thoughts and recommendations regarding Army transformation.

2. A PLATFORM-CENTRIC APPROACH

As a result of transformation, Army forces will be capable of both strategic and tactical mobility. To engage in combat operations the Army will no longer mass and then attack but will mass and attack simultaneously. For the attack to be successful, mobile Army forces must be capable of bringing to bear sufficient firepower and must be capable of surviving the engagement. It is the trade-off between mobility, survivability, and lethality that presents the greatest challenge to transformation based on reducing the weight of a single platform.

The Army is already addressing this by developing 20-ton platforms that can be deployed rapidly. The Army is currently delivering six *Stryker* brigade combat teams (BCTs) to fill an operations gap between the Army's heavy and light forces. Two *Stryker* BCTs have already been delivered, the 3rd Brigade, 2nd Infantry Division (presently serving in Iraq), and the 1st Brigade, 25th Infantry Division (Light Infantry). In addition, the Army is developing a set of manned and unmanned ground vehicles, and unmanned aerial vehicles collectively referred to as the Future Combat Systems (FCS). To insure their rapid deployment, both the *Stryker* family of vehicles and all FCS platforms are required to fit inside a C-130. Whereas *Stryker* is designed to fill a current need, FCS is intended to replace over a thirty-year period all platforms currently employed by the Army.

In plain terms, FCS is intended to provide the Army's Future Force with the mobility of its existing airborne units and the firepower of its existing heavy divisions. This dilemma, developing a force with the mobility of light infantry and the firepower of armor, has been with the Army since World War Two, when Army ordnance engineers first tried to build a light tank that could be

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carried by a glider and landed with parachutists and glider-borne infantry. Since that time, the Army has struggled to produce a mobile vehicle under 20 tons in weight that is capable of delivering impressive firepower yet also capable of protecting its crew.

World War II and post-war light tanks, tank destroyers, and gun platforms were designed primarily to protect light infantry against tanks and against infantry supported by tanks (Hunnicutt 1992, Hunnicutt 1995). Thus, emphasis was placed on lethality and survivability, not mobility. As light tanks confronted more powerful threats, they became heavier. The reasons for this increase are two-fold, heavier munitions were required to combat the more powerful threats and more armor was necessary to protect platform crews.[1] Light tank development came to an end in the 1950s, when a tank like the M41A1 was almost as large as a medium tank of World War Two. Eventually, the Army abandoned the light tank concept altogether.

Mobility and lethality were emphasized in alternate versions of the light tank designed to provide firepower to airborne forces. In World War Two the Army developed the M22, which could be carried by a glider. But the lightly armored M22 did not provide adequate protection against the tanks it was likely to meet on the battlefield. When the Army tried again in the 1950s to provide firepower to airborne forces, it sacrificed protection completely in favor of firepower and mobility. The result was the M56 gun platform, which was a 90-mm gun mounted on a tracked chassis with no armor for the crew. There was also little armor for the tracked M50, which carried six 106-mm recoilless rifles. The M50 sacrificed both crew protection *and* mobility in favor of firepower. The assumption of its developers was that the M50, because of its small size, might be able to ambush larger enemy vehicles and overwhelm them with a massive salvo from a simultaneous discharge of several or all of its six recoilless rifles. (Similar thinking has been applied to the design of the FCS.)

In contrast to the light tank, armored infantry fighting vehicles (IFV) were designed to minimize weight and cost, and maximize protection for the infantry carried inside (Hunnicutt 1999, Hunnicutt 2001). The first vehicle, the 1942 half-track, was produced in great numbers during World War Two only because the Army had little better to offer and the need to field some form of protection for mechanized infantry was great. The half-track's armor was thin and could be penetrated by .50 caliber bullets, and its front-mounted engine made it vulnerable.

The Army's first real IFV was the M44 of 1946. The M44 provided adequate protection for the infantry it carried, but its combat weight at 51000 lbs. limited mobility and dramatically increased cost. The M75 and M59 of 1953 weighed less than the M44 and actually provided increased protection for infantry but were too heavy to be airlifted and neither could float.

The M113 finally met the needs that the Army had set for such vehicles in World War Two. It was light, easy to produce in large numbers, mobile (suitable for air transport and capable of "swimming" across small rivers), and capable of protecting the infantry it carried from machine gun fire and shell fragments. As a result, the M113 spawned a family of vehicles for tasks such as command and control, engineering, indirect fire support (from a mortar carried inside the vehicle), and even chemical smoke generation. The M113 was such a success that variations of the basic model are still in active service, and the newer M113A3 was even put forward as an alternative to the *Stryker* wheeled vehicle.

Consider what happens when designers shift the balance among the variables of firepower, mobility and protection for IFVs. The M2 Bradley IFV, for example, has significantly more firepower than the M113 and somewhat better protection for the soldiers it carries. But it is also significantly heavier than the M113, and heavier even than the M113A3, so it cannot be air dropped. That is, it sacrifices an element of mobility in favor of increased firepower. (Indeed, the M2 and its brother the M3 provided significant levels of organic fire support to mechanized infantry engaged in combat in Iraq.)

This historical discussion sustains the general point we wish to make: There are unavoidable physical constraints placed on platform development. If the objective is firepower, for example, one has to pay for it with some other factor, whether mobility or protection. The World War Two half-track, for example, served as the platform for a variety of weapons, from quad-mounted .50-caliber machine guns to 57- and 75-mm anti-tank guns. But it gained that increase in firepower at the expense of survivability on the battlefield. In the M113, the Army chose to emphasize mobility instead of firepower.

In recent years, the proliferation of infantry-carried rocket propelled grenades with shaped-charge warheads has increased concern for protection. This is especially true for *Strykers* deployed in Iraq, whose armor is not capable of withstanding a hit by an RPG. To counter the threat, so-called slat armor has been added to the *Stryker's* exterior. The spacing between the slats is such that it pinches the cone of an RPG and causes it to detonate before impact. Slat armor first proved its value in January 2004 and again, more famously, in February during a visit to Iraq by Assistant Secretary of Defense Paul Wolfowitz. However, the armor adds weight to the vehicle and must be added on after deployment.

Although advancements in technology have led to the development of ceramic- and composite-based lightweight armors capable of surviving a hit from a medium-caliber weapon (smaller than 30 mm), this falls

[1] In 1941, a 37-mm gun provided adequate lethality. But the M24 of 1945 carried a 75-mm gun and the M41A1 of 1953 carried a long-barreled 76-mm gun. The M24 weighed 40500 lbs., while the M41A1 of 1953 was significantly heavier, at 51800 lbs.

short of the M1A1 Abrams' ability to withstand a 125-mm round. Thus, as we have indicated, increasing protection means reducing one of the factors we have already discussed, unless some technological breakthrough introduces a new factor and eliminates the need for the conventional trade-offs in weight.

Even if a material could be found that provided the same protection as the armor on the Abrams but without adding to platform weight, a 20-ton platform still remains vulnerable. Consider that, because the mass of a 20-ton platform is 3.5 times less than that of an M1A1, if both are hit with the same force, the lighter platform will be accelerated 3.5 times faster than the M1A1. The consequences of running over a mine are therefore more severe for a 20-ton *Stryker* or FCS platform than they are for an Abrams or Bradley.[2]

A 20-ton platform must therefore be aware of its surroundings and must be sensitive to potential threats. Countermine sensing is therefore important, as are active protection systems, for lightweight platforms. Active protection systems are designed to sense a round and deflect or destroy it prior to penetration (using, for example, ejecting armor plates to alter trajectory) or defeat it in some manner after penetration. The Army expects that initial FCS platforms will be capable of defeating shaped charge weapons and RPGs, but the deflection of larger munitions or kinetic-energy rounds is not expected for another decade. The development of stealth technology for ground vehicles as a means to avoid detection is also not expected to mature for another decade.

Due to the simple trade-off between weight and speed, none of the previous attempts to provide lethality, mobility, and survivability within the physical limits of a single platform have done so satisfactorily. Put simply, increased lethality or survivability constitutes an increase in weight, which reduces vehicle mobility. Despite efforts to improve passive protection through new material development, if vehicle size and weight are specified for maximum mobility, increased survivability and lethality can be achieved only by exploiting capabilities outside the confines of a single platform. The FCS program therefore attempts to make its platforms more aware through active protection technologies.

But just making platforms more aware is not enough to achieve the Army's goals of mobility, lethality, and survivability. Awareness must spread across the battlefield. It is for this reason that the Army is interested in shifting its emphasis from developing only *platforms* to developing a *system of systems*. To truly meet the Army's goals for transformation, old constructs need to change and new degrees of freedom need to be introduced. The core of the Army's present solution relies upon the deployment of network technologies, which we discuss in the next section.

3. A NETWORK-CENTRIC APPROACH

If conventional trade-offs alone are insufficient to meet the Army's transformation goals, new ones need to be considered. The trade-off the Army seeks to make, at least euphemistically, is information for armor. We feel it is important, though, to indicate that information has always been critical to military operations. Whether for obtaining situation awareness or conveying a commander's intent, militaries have consistently employed the most advanced communications technologies of their day to convey information. Thus, the focus of transformation is not so much information exploitation as it is deploying and exploiting network-based technologies. It is important for us to re-emphasize that a platform-centric approach to transformation, which relies on deploying 20-ton platforms, is inherently dependent upon the network to insure its survivability.

The emphasis on deploying network technology on the battlefield is little different in spirit than previous efforts to bring computing technology to the battlefield. Consider for example the mission of fire control. The first automated fire control system, the field artillery digital automated computer (FADAC), was fielded in 1959. (Weik, 1961) The transistor-based FADAC was essentially a special purpose calculator that occupied 5 cubic feet, weighed 175 lbs., and consumed 700 watts. Using manually entered data, the FADAC calculated and displayed gun orders (i.e., gun deflection, quadrant elevation, fuze time, and charge) on 16 numerical indicator vacuum tubes. Fire control capabilities were expanded and automated with the development of the tactical fire direction system (TACFIRE), first fielded in 1978. (Carey, 2002) In 1992 the light tactical fire direction system (LTACFIRE) for light forces and the initial fire support automated system (IFSAS) for mechanized forces were fielded to provide capabilities similar to TACFIRE but with equipment considerably smaller in size. In 1997 the advanced field artillery tactical data system (AFATDS), which relies upon digital communication to conduct command and control, replaced these systems. (Boutelle, 1996)

Artillery's efforts to automate its fire control mission were mirrored in other branches, and in the other services, as each automated its respective mission. Unfortunately, in so doing, the foundations for the now-proverbial stovepipes were laid. However, these stovepipes resulted as a consequence of the available technology and not through any oversight or lack of imagination. Given that the Internet was in its infancy in the 1970s, it was difficult to plan for a networked force.

[2] This unavoidable fact of physics also has implications to lethality. A platform must be able to withstand the recoil from a gun and large caliber munitions produce large amounts of recoil. However, this can be ameliorated by attaching the platform to the earth using retractable pinions and, thus, adding the weight of the earth to the platform when firing.

Yet, while the fire control mission became more automated and linked in the early 1990s, the commercial world was becoming interconnected. By the time AFATDS was delivered some of its shortcomings were obvious. The maturing in the 1990s of networking technology and the tools for its use made the employment of networks by the military a reality. As a consequence, it is now possible to pursue the integration of stovepiped mission applications. For example, when sensors are networked to fire control and fire control is networked to logistics it is possible to remove threats in a timely manner and insure timely resupply of depleted munitions.

The most visible application of networking to the battlefield is the Force XXI Battle Command, Brigade-and-Below (FBCB2) system, presently deployed with the 4th Infantry Division in Iraq and on all *Stryker* platforms. Through its capabilities in position-navigation and reporting, combat identification, and its interface to terrestrial communications, FBCB2 provides situation awareness and command and control to the lowest tactical echelons. For operations over long distances or rugged terrain, there is also an interface to satellite communications.

FBCB2, also referred to as "blue force tracker" for its ability to track and display the movement of friendly forces, provides real-time situational awareness for commanders, staff, and soldiers. It also provides a shared common picture of the battlespace, with the locations of friendly and enemy unit indicated on graphical displays.

FBCB2 is a system of approximately 1000 computers networked in a single maneuver brigade. The network is based on a fixed set of addresses. Prior to deployment, the network must be planned, and addresses assigned and loaded. At a hardware level, planning also entails assigning frequencies and circuits. Once operations have commenced, network resources must be constantly monitored and managed to reconfigure the network and deactivate circuits. That is, the system is presently incapable of starting, operating, and gracefully degrading of its own accord under all conditions without human intervention. Network reconfiguration and deactivation are not autonomous.

Given that the network is critical to survivability, the amount of latency, or delay, is a critical parameter and reconfiguring the network manually robs operations of precious time. Thus, the conditions faced by mobile ground forces dictate an ad hoc network. That is, the network must be capable of reconfiguring itself constantly as nodes come onto or fall off of the network. Unfortunately, the mobile ad hoc network (MANET) protocols necessary to sustain the network reliably remain under development and the Internet Engineering Task Force, the protocol engineering and development arm of the Internet, has not yet accepted any standards.

The utility of mobile ad hoc networking has already been demonstrated in DARPA's Small Unit Operations Situational Awareness System (SUO SAS) and in DARPA FCS Communications. SUO SAS is a MANET-based networked radio designed for a unit cell of 20 dismounted soldiers. It was successfully demonstrated in a simulated helicopter rescue at Ft. Benning in October 2002 and has since been transitioned to the US Army Communications-Electronics Command for further development. In August 2003 FCS Communications demonstrated a MANET-based networked radio system for a unit cell of 20 ground vehicles and 2 aerial vehicles in a mock operation at the Army National Guard Orchard Training Area in Boise, Idaho. FCS Communications demonstrated 10 megabytes per second data rates with latency on the order of 100 milliseconds. This performance is needed to support real-time fire control and robotic missions yet provide robustness to jamming and low probability of detection. FCS Communications uses both directional antennas at low frequency bands, which match frequencies allocated for the Joint Tactical Radio System (JTRS), and directional antennas at millimeter-wave frequencies. The JTRS is a software based radio system currently being developed as the primary radio for providing communications to the military.

DARPA's efforts demonstrate the maturity of the communications technology that forms the infrastructure of the Future Force network but by itself does not provide any operational capability. Operational capability is provided by the applications executed over the network. This capability has yet to be demonstrated, but is currently under development. Mobile command and control is the focus of the Agile Commander Advanced Technology Demonstration (ATD) under the direction of the Army's Communications-Electronics Command and DARPA's FCS Command and Control program.

Further, the Department of Defense, through programs such as the Global Information Grid (http://www.defenselink.mil/nii/org/cio/gpmlinks.html) and Transformational Communications (http://www.nro.gov/PressReleases/prs_rel63.html) are establishing the backbone to support the flow of data required for networked communications and are establishing data standards and databases that will allow for data access across platforms. These programs rely upon a fixed infrastructure of landlines, wireless, and satellite communications to provide sufficient bandwidth and communications capability to allow Corps and Division headquarters to reach back for information.

However, the immaturity of application development and execution for mobile networks raises the risk in deploying network technology to the battlefield. Once deployed, the applications must remain stable as the network is constantly reconfigured. Failure of an application leaves ground forces vulnerable and dependent upon the platform technologies for survivability discussed in Section 2. Indeed, recognition of this is reflected in the philosophy used to design FCS survivability: don't be seen, don't be targeted, don't be hit, don't be penetrated, and don't be killed. The assumption is that network technologies, in combination with stealth, will confound the ability of a ground vehicle to be seen or targeted. When these fail, active and passive vehicle protection technologies, as well as personal protection, are required.

As an aside to this discussion, we claim the Army's insistence that all platforms satisfy the C-130 requirement is indicative of platform-centric thinking. Yet critics of the FCS that point to vulnerable 20-ton platforms are guilty of the same offense. A networked approach to warfare requires a networked, or integrated, notion of survivability. If transformation implies moving philosophically from a platform-centric military to one that is network-centric, survivability encompasses not just the likelihood of a crew surviving a hit by a particular munition but also the likelihood that a platform will be targeted and fired upon. From a strategic perspective, survivability becomes an integrated measure across the battlefield and across the mission. Advocates of network centric warfare believe that by exploiting information it is possible to reduce this likelihood and thereby increase overall survivability.

In this regard, the Army's approach to survivability is correct. Removing potential threats before they become deadly threats and replacing large signature ground vehicles with a distributed collection of low signature ones, some manned and some unmanned, reduces the density of combatants, reduces observability, and reduces the likelihood that they will be targeted. However, this solution relies upon technologies that remain immature and untested. Framing Army transformation in terms of a system of systems is correct, but relying heavily on network technologies to enhance the survivability of 20-ton platforms is risky.

Although the potential capabilities that network technology can bring to the battlefield are obvious, there exists little quantitative data to date to substantiate their impact. That is, it is not yet possible to determine how many fewer ground platforms are required as the number of nodes on the network increases or how much lighter ground platforms can be made. Increasing the speed of transmission and the number of unfettered transmission links certainly allows the Army to improve execution of its present missions. But no data exists that allows one to calculate the advantages of networking in terms of force multipliers. We are not suggesting that work towards this goal be stopped or slowed. However, considerable effort remains to be done.

It is these inherent risks that prompt us to consider an alternate, near-term approach to transformation in the next section. This approach does not rely upon technology but on the disposition and organization of Army forces to redistribute, not reduce, its weight.

4. TRANSFORMATION BASED ON FORCE STRUCTURE

The lynchpin of the Army's present transformation efforts is the requirement that all platforms be C-130 transportable. This constraint reflects one interpretation of the link between weight and deployment, the one addressed in Section 2. It drives the need for active protection and network technologies to insure the survivability of lightweight platforms designed conventionally for mobility. However, other interpretations exist, namely, that future Army forces should be lighter, not because their individual platforms weigh less, but because their total mass, inclusive of large support structures, is reduced. Even though the Army has already trimmed some assets from its old Cold War model, the current heavy corps of three divisions and 103000 troops still weighs one million tons. See Table 1.

Table 1. Illustrative Estimate of Army Heavy Corps Weight

Unit	Weight (tons)
Armored cavalry regiment	23000
3 heavy divisions	330000
Separate heavy brigade	27000
Corps combat support	100000
Corps combat service support	100000
Echelons above corps	55000
War reserve munitions and stocks	365000
Total	1000000

Source: Department of Defense, Military Traffic Management Command, "Deployment Planning Guide, Transportation Assets Required for Deployment," MTMCTEA Pamphlet 700-5 (Military Traffic Management Command: Newport News, VA, May 2001).

Why do Army forces weigh so much? Some point to such heavy equipment as the Abrams tank, Bradley IFV, and Palladin artillery tubes as the principal reason armored or mechanized divisions weigh fully 110000 tons, far more than the 68000 tons of a standard infantry division. Yet these platforms account for only about 20000 tons of a heavy division’s weight while providing half its combat power and virtually all its offensive punch. By comparison, the 101st Air Assault Division, which relies upon light infantry and attack helicopters and, therefore, has few tanks and IFVs, nonetheless weighs 100000 tons due to its many helicopters and associated support assets.

Although a heavy division and its support assets require 50 or more cargo ships of sealift, even a 17000-ton light division can require nearly 40 ships due to its support assets. Since sailing consumes nearly two-thirds of the time needed to ship forces to the Persian Gulf, and loading and off-loading only one-third, a light division may arrive in the Persian Gulf only a few days sooner than a heavy one. Often the marginal change in deployment is insufficient to justify the loss of combat power when a light division, as opposed to a heavy one, is deployed. (Past efforts to provide light infantry and airborne divisions the firepower of a heavy division are discussed in Section 2.)

We note that replacing the existing tanks, IFVs, and artillery tubes with 20-ton FCS vehicles reduces the weight of a heavy division from 110000 tons to 95000, approximately a 15% reduction. Further, the weight of a three-division heavy corps (armored or mechanized) drops by only 7% from one million tons to 930000 due to support units, such as maintenance, engineers, truck transport, ammunition handling, military police, and medical assets.

If light vehicles are fielded in large numbers, a medium infantry brigade will require about 500 C-130 sorties for its maneuver units plus an additional 200-300 sorties for its logistic support and sustainment stocks. Whether the Air Force is capable of making available such a large number of sorties, while attending to all its lift requirements, is problematic at best. The bottom line is that, even though it is reasonable for the Army to contemplate airlifting a single brigade of light vehicles swiftly into a hot combat zone, larger formations will have to be transported by sealift, which, unless other changes are made, will still take between two and three months to deploy.

A simple way to speed the deployment of Army forces is increased prepositioning of Army equipment overseas. The most likely places for future combat are, for the most part, known. Today the Army has eight brigade sets positioned in Europe, Southwest Asia, and Asia. It already possesses ample numbers of tanks, IFVs, artillery tubes, and other weapons assigned to war reserves and National Guard units that could be used to form additional prepositioned brigade sets. Creation of another six to eight equipment sets would be costly, but it would significantly accelerate the rate at which Army combat forces can deploy. Ideally, such equipment sets should be deployed afloat, aboard ships that can quickly sail to crisis zones. Redistributing weight through prepositioning is worthy of discussion but does not address a more fundamental issue. If the Army's existing armored corps, with its weight of one million tons, is too big and ponderous, what type of formation or formations should replace it in order to deploy rapidly and still fight effectively?

Consider that transformational thinking at the tactical level evolved the aggregation of individual platforms to create mass into an integrated system of systems. Advantages derive from a system-of-systems that is comparable in capability to the aggregation of mass but is more dispersed and requires fewer resources. Applying similar thinking at the operational level leads to capability-based combat groups, smaller than today's standard divisions and constructed in a modular fashion with interfaces to joint structures, for example, for fire support, and with "hooks" to allow the integration of combat groups into corps-like structures for different missions. (Macgregor, 1997)

Macgregor has proposed restructuring a corps into four combat groups for armed reconnaissance, combat maneuver, strike, and early-deployed support. Fundamental to the operational architecture is the reduction in logistics and recognizing that fire support and C4ISR are joint operations, not Army. Some of the groups, especially the light reconnaissance strike group, are dependent upon the network technology discussed in Section 3. Truly transformational benefits could be derived if the Army were to deploy this technology into organizations designed with the technology in mind.

However, in the mid-term, reduced logistics can be achieved via an armored corps of 65000 troops with six or seven maneuver brigades. For medium-sized contingencies, this new force should allow a single, strong Army corps to converge and begin fighting more rapidly than now. In effect, to take a "running start," as opposed to waiting for large sustaining assets to deploy over a period of days and weeks.

Similar to Macgregor's proposals, the reduced corps should be modular by design. That is, it should be able to deploy and fight as a cohesive unit at its normal size of 65000 troops, but have the capacity to inflate to 103000 troops when situations mandate greater strength. For large contingencies, two of these reduced corps could deploy in the same time that a single corps can deploy today. The result will be more combat power for initial battles. If necessary, extra sustainment assets can be deployed *after* key combat and support assets have arrived. Had this force been available for *Operation Iraqi Freedom*, the Army may have been able to deploy several more combat brigades than the seven actually deployed on the first day of the engagement. The cost would have been less logistic support and long-term sustainment, but the benefit may have been the quick victory sought by U.S. strategy.

Our proposal differs from the conventional practice of stripping down a big corps to improvise a smaller one. Although the Army already has a capacity to deploy a small corps by stripping down its parent version, this runs the risk of hasty improvisation and compels Army forces to fight in ways other than those for which they were trained and prepared. Among other things, the current big corps lessens the incentive to think jointly in terms of integrated air-ground fires. It also creates a rationale for postponing aggressive combat operations until the full set of big-corps assets is on the ground.

Instead, we propose the creation of a small corps as the norm, and to generate large corps as an exception to the rule. The Army thus would anchor its doctrine, training, and practices for expeditionary warfare on a small corps, while still having the flexibility to employ large formations. In other words, the Army would learn to think small in more ways than one, while retaining the capacity to think and act big as well.

Can such a smaller corps be created? While the answer is uncertain, the search for a solution should be anchored in the premise that in expeditionary wars, U.S. forces will normally be fighting enemies that are less well armed and less capable than the Soviet army of the Cold War. Moreover, the increased lethality of Army weapons allows ground combat forces to destroy more enemy targets and occupy more territory than in the past. As a result, the future force may need fewer fire and maneuver assets than now. Above all, it will need fewer sustainment assets for prolonged conflicts because most expeditionary wars are likely to involve less-intense combat, consume fewer resources, and be finished quicker than the big wars of the past. These propositions provide a basis for thinking about structural changes that might become possible as the information age accelerates and new technologies enter the inventory.

During the Cold War, operational plans typically committed only about one-half of a corps' maneuver battalions to the forward battle in the initial stages. The remaining battalions were held in operational reserve and mainly were intended to function as unit replacements for forward-committed units that were expected to suffer heavy attrition. This practice remained the case even as the Army shifted from linear defense to non-linear operations. During the famous "left hook" of *Desert Storm*, a surprising number of maneuver battalions assigned to 7th Corps and 18th Corps were withheld as tactical reserves and never saw combat.

Further, because initial attrition for future expeditionary wars will be lower than the Cold War model, and because many forward-committed battalions will be able to perform their missions without big reinforcements from rear areas, the future corps may require only 6-7 maneuver brigades. Beyond this, the introduction of remote, standoff-fires promises to further increase the lethality of Army forces, thereby lessening the requirement for close-combat capabilities. If the elimination of three combat brigades proves feasible, the weight of a heavy corps can be reduced directly by 100000 tons and indirectly by another 100000 tons by reducing support needs.

To further enhance U.S. capabilities for swift force deployment the creation of additional brigade sets should be combined with programs to strengthen U.S. airlift and sealift forces and a program to develop better military infrastructure in distant areas where operations might become necessary. Likewise, improvements to the planning process for strategic lift and power projection can also help, including the improvement of processes within the Transportation Command.

The main goal here is to design a swift and agile Army corps that can deploy quickly and fight effectively in the initial stages of an expeditionary war. With such a new and leaner structure, the key combat and support forces for one or two corps could arrive and begin operations without waiting for additional large sustainment-oriented assets to arrive. But because this smaller corps is modular, it could absorb such assets if and when they are deployed later. Thus, the combat and support assets taken away from their parent corps would remain in the Army force posture, and could be deployed when they are needed. They would help form a flexible pool of assets that would help contribute to a more modular, scalable Army structure for its current force.

5. FINAL COMMENTS AND RECOMMENDATIONS

The transformation of the Army is a multifaceted problem, which suggests many solutions. The point to our discussion in the previous sections is that, placing the platform at the center of transformation efforts is insufficient to meet the Army's transformation goals in the near term. Enhancing the platform with lightweight materials requires considerable research and development, and the platform must still rely upon new sensors and network technology to insure its survivability. Although networking technology is an attractive alternative to provide additional capability to ground forces, our research indicates that the technology required by mobile ground forces is immature. Thus, the Army's reliance on information technology to insure the survivability and lethality of lightweight, mobile ground vehicles entails high risks. Failure has acute consequences. Ground vehicles and ground troops must bear the brunt of any deficiencies in the network. However, this does not negate the need to invest in advanced technologies like active protection and networks. On the contrary, the capabilities they provide are applicable to all Army ground vehicles.

As we emphasized in Section 2, increased conventional protection can be obtained by allowing platform weight to increase. We feel that deployment of a network-enabled 35-ton ground vehicle, comparable to the Bradley IFV, provides a level of survivability with which most troops would feel comfortable should the network fail and leave them vulnerable. This hedge against vulnerability is important to allow troops to train confidently with the technology and develop the tactics to allow network-centric warfighting to reach its fullest potential. Operational engagements are not the time to experiment wholeheartedly, in option-sacrificing ways, with untested technologies that might go awry when confronted by the real world of wartime fog and friction.

The natural response to removing the weight constraint is to question its impact on strategic mobility. However, as we indicated, the change in platform weight will have little impact on the movement of large force structures. Further, increased mobility can be achieved by using fast sealift and pre-positioning equipment on land and at sea. Most importantly, mobility is not just about speed but about what is being moved. We feel that changing force structure will have a greater near term impact on deployability than new technology for lightweight platforms.

Creating smaller units is an obvious means to reduce weight and the new Army Chief of Staff has recently proposed his plans to alter the present brigade structure to make create smaller, leaner brigades. The Chief's proposal addresses concerns about current readiness, not future force capabilities.

In the coming years, the Army will be called upon to deploy combat forces in varying sizes: battalions, brigades, divisions, corps, and multiple corps. Deployment problems are not the province of large forces alone. Such problems can arise in trying to deploy a single brigade or even a battalion. But as *Operation Iraqi Freedom* shows, these problems arise with special magnitude when heavy corps-sized forces are deployed. If the Army can acquire a better capacity to deploy swiftly one or two corps on a single occasion, it likely will be able to deploy smaller forces or larger forces at effective rates. Regardless of whether the term corps remains part of the future vernacular, the Army will continue to anchor its planning on corps-sized operations, and it will use this model as a basis for operating in big and small ways.

In a strategic environment that expects the military to engage in expeditionary warfare more often than it has in the past, the Army will be stressed to balance its requirements for mobility, lethality, and survivability. Up till now, much of the Army's focus has been on technology and, in particular, the technology required for its so-called unit of action. But, as we have shown, simply replacing heavy platforms with lightweight ones does little to change the total weight of Army forces. As such, more thought needs to be given to organizational structures within which the technology will be used. By exploiting parameters that exist outside a single platform it is possible to shift one's thinking about a collection of platforms from an aggregated mass to a system-of-systems. Similar thinking needs to be applied to organizational architectures. Only by considering forces in their totality is it possible for the Army to meet future challenges.

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